REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY *(LEAVE BLANK)*	2. REPORT DATE 27 September 1995	3. REPORT TYPE AND DATES COVERED Professional Paper

4. TITLE AND SUBTITLE

E-6A Precipitation Static Assessments

5. FUNDING NUMBERS

6. AUTHOR(S)
Joel Haines
Mike Clelland
Mke Whitaker

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Visual and Technical Information Branch
7.2.4.3.A, Mail Stop 2, Bldg. 405
Naval Air Warfare Center Aircraft Division
Patuxent River, Maryland 20670-5304

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Naval Air Systems Command
Department of the Navy
1421 Jefferson Davis Highway
Arlington, VA 22243

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release, distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

SEE ATTACHED PAPER

14. SUBJECT TERMS
Combat System Test Bed;R&D,Mobile Demonstration

15. NUMBER OF PAGES 32

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	N/A	N/A

E-6A
PRECIPITATION STATIC ASSESSMENTS

Joel Haines, Mike Clelland, and Mike Whitaker
Naval Air Warfare Center Aircraft Division
Code 5.1.7.2
Patuxent River, Maryland 20670-5304

William DePasquale
Dual, Incorporated
745C Great Mills Road
Lexington Park, Maryland 20653

Bernd Lubosch
Dual, Incorporated
5600 Liberty Parkway
Midwest City, Oklahoma 73110

Electromagnetic Environmental Effects (E^3) is a serious concern in today's Navy. As part of the E^3 life-cycle effort, P-Static Assessments of TACAMO Fleet aircraft are being conducted. These assessments are used to monitor aircraft bonding integrity and maintenance procedures throughout the aircraft life-cycle. To minimize the problems associated with E^3, aircraft bonding integrity must be maintained.

A P-Static assessment is a quick-look method for finding bonding inconsistencies on the skin of the aircraft. Working hand in hand with the Fleet, problem areas can be identified and maintenance actions initiated to correct them. In the future, the P-Static assessments will be incorporated into the Enhanced Phase Maintenance (EPM) procedures.

The P-Static assessments consist of power off testing along with dc bonding measurements of the static discharging system. The Fleet receives a brief report describing problems found during the assessment with recommended fixes. A database will be developed to document all problem areas and note any similarities between aircraft.

Enclid

INTRODUCTION

To ensure that the level of electromagnetic pulse (EMP) hardening will be maintained throughout the life of the E-6A aircraft, the Hardness Maintenance/Hardness Surveillance (HM/HS) program was implemented. HM is a set of comprehensive procedures to ensure that Fleet operations, logistic support, and/or maintenance do not degrade the designed EMP hardness. HS includes system level and field surveillance tests and inspections performed throughout the aircraft life-cycle to monitor hardness integrity. As part of the HM/HS plan, Precipitation Static (P-Static) assessments of the Take Charge and Move Out (TACAMO) Fleet aircraft are being conducted.

P-Static testing is performed by using a high voltage test set to deposit a charge onto the aircraft with a high voltage ion discharge wand. Any unbonded panels, screws, rivets, doors, etc. can contribute to electromagnetic interference (EMI). This EMI can disrupt aircraft communications equipment and, in turn, impede the mission of the E-6A. Panels can become unbonded through the normal course of operations. Proper bonding of panels to the airframe can alleviate a high percentage of P-Static problems.

Standard test methods and equipment will give the Fleet the ability to protect the E-6A aircraft and its systems from P-Static problems. Early detection will preclude the necessity for a major test program to fix P-Static related problems. P-Static testing can identify electrically isolated areas, evaluate static wick performance, measure static wick parameters, test lightning diverter strips, and identify affected avionics.

The E-6A mission is primarily communications. A major P-Static problem could adversely affect the ability of the aircraft to perform its mission. Further mission communication upgrades to the E-6A, like the E-6A Avionics Block Upgrade (ABU) and the E-6B Airborne National Command Post (ABNCP), require that EMI caused by P-Static be kept at a minimum. For this reason, a P-Static assessment program is being put into place at the Fleet maintenance level.

The E-6A E^3 Hardness Maintenance / Surveillance (HM/S) Integrated Product Team (IPT) is responsible for performing system level hardness assurance and surveillance tests, evaluating and developing test equipment capable of monitoring and detecting EMP hardness degradation, providing on-site life-cycle E^3 HM/HS technical and engineering support to the Fleet, as well as integrating P-Static into the Enhanced Phase Maintenance (EPM) plan. The scope of this paper is to discuss the HM/S IPT's current plans on P-Static.

Since 1990, all E-6A aircraft have undergone EMP HS field. All testing performed by the HM/S IPT is done on a not to interfere basis with the Fleet. P-Static testing is performed in the same manner. One HM/S IPT member and one Fleet maintenance personnel conduct the test in one 10 hour shift. Standard test methods and equipment give the TACAMO Fleet the ability to protect the aircraft and its systems from P-Static problems.

TEST RESULTS

Currently, P-Static evaluations have been performed on three E-6A aircraft (BuNo 164387, 164388, and 164408). Evaluations on each aircraft produced similar results. Several panels on the engine struts were not bonded properly to the aircraft. Also, panels on the vertical stabilizer were not properly bonded. The following table is an example of some of the problem areas found during these assessments.

LOCATION	THRESHOLD $\mu A/ft^2$	SUGGESTED FIXES
TWO HINGES ON AFT SIDE OF THE FLIGHT RECORDER PANEL (#10/96), BOTTOM OF VERTICAL STABILIZER	10	BOND HINGES AND PANEL TO AIRCRAFT
HF LIGHTNING ARRESTOR PANEL (#911-01), TOP OF VERTICAL STABILIZER	10	BOND PANEL TO AIRCRAFT
#1 ENGINE STRUT ACCESS PANEL L10133-05	15	BOND PANEL TO AIRCRAFT

When the problem area list is given to Fleet maintenance personnel, the process of correcting the problems is initiated. Generally, these fixes are uncomplicated. Installation of a bonding strap is a typical fix for bonding problems.

The P-Static test set can be used as an EMI trouble shooting tool as well. For example, E-6A BuNo 164408, was having such severe EMI problems that its VHF/UHF radios were virtually unusable. Using the P-Static test set, it was discovered that a lightning diverter strip on the nose radome was improperly installed, leaving it unattached to the aircraft. With the electrical charge buildup, arcing across the gap between the lightning diverter strip and the aircraft began. This arcing was being picked up by the VHF/UHF communication system, raising the noise floor of the radios so high that voice communication was impossible. A bonding strap was installed as a quick fix for the next flight. A metal plate was later installed as a permanent fix.

A baseline of all Fleet E-6As, including the ABU and ABNCP aircraft, is planned.

TEST METHODOLOGY

Currently, ground testing of aircraft at Tinker Air Force Base is performed using widely accepted test methods in the electrostatic field. Testing is performed by using a high voltage test set to deposit a charge onto an aircraft with a high voltage ion discharge wand. The wand is comprised of a high voltage dish with electrostatic dischargers attached, which enables the wand to "spray" a simulated P-Static charge onto the aircraft.

Each area of the aircraft is sprayed at 40 kV and approximately 50 $\mu A/ft^2$ current while sensitive hand-held receivers are monitored for any electromagnetic interference (EMI) generated by P-Static. Because the wand is comprised of electrostatic dischargers, P-Static noise generated by the wand itself is almost nonexistent, thus enabling a very effective test method for aircraft. EMI is generally produced due to arcing between

isolated sections of the aircraft. However, problems have also occurred due to corona discharge from the aircraft and streamering effects.

Noise generated on the receivers can be heard in the form of popping, motorboating or squealing, depending on the severity of the P-Static problem.

After the entire aircraft has been sprayed, the areas with the most serious P-Static problems will be identified. Then the actual aircraft radios or equipment to be tested for P-Static interference can be monitored while each problem area is resprayed at 20 $\mu A/ft^2$ current. This current level has been determined to be severe for inflight P-Static induced on Navy aircraft. However, because the design of the high voltage test set is dynamic, testing can be performed at any voltage level up to 40 kV and any current level up to 200 μA. Also, because each problem area can be examined closely, a solution can readily be determined (such as installing a bonding strap).

Testing for P-Static interference is not the only use of the high voltage test set and wand. Additionally, specific checks can be performed on each aircraft static discharger to examine proper discharging capability. A poorly performing discharger will generally begin arcing and generate noise on the hand-held receivers. Also, the wand can be used to find dischargers which may be installed on isolated panels (thereby becoming less effective for dissipation of electrostatic charge from the aircraft). Finally, the wand can be used to test a fix installed on a problem area to ensure that P-Static no longer presents a problem in that area.

During a standard P-Static evaluation, other instrumentation is used to augment testing. A Digital Low Resistance Ohmmeter (DLRO) is used to check bonding of the aircraft. Bonding checks can be made of installed electrostatic dischargers, fuel tank cap or vent areas (for safety), and also between isolated sections of the aircraft's surface. Bonding checks can be made to determine if the aircraft discharging system functions are in compliance with MIL-B-5087B (1), the current bonding specification for Naval aircraft.

Also, a digital megohmmeter (megger) can be used to check the tip to base resistance of electrostatic dischargers to be used on aircraft, whether installed or not. This will determine compliance with MIL-D-9129D (2), which gives the current specification limits for Naval aircraft dischargers. This can be used to determine if the discharger has internal damage and may need to be replaced.

All of these test methods are relatively simple to accomplish. However, for the testing to be accomplished correctly and consistently, standard documentation will also be necessary. These will include standard test procedures, detailed operating procedures and equipment maintenance documents. Currently, all three types of documents are available for P-Static testing of aircraft at Patuxent River. However, this documentation can be tailored for testing at the Fleet level.

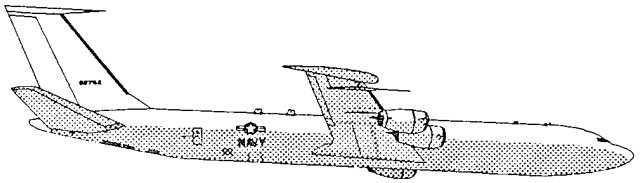
If this test methodology can be incorporated into EPM, then the Fleet will have the capability and expertise to test the E-6A aircraft for problems related to P-Static, without the need for a large test program.

Currently, the Naval Air Warfare Center at Patuxent River is tasked to provide Fleet support and has distributed a P-Static equipment and documentation package to the E-6A Fleet at Tinker Air Force Base, Oklahoma City, OK.

SUMMARY

By incorporating standard test methods and equipment into the Fleet, a reliable system of Precipitation Static ground testing of Fleet aircraft can be established. It will provide a relatively simple means of evaluating the E-6 aircraft and its systems for P-Static effects during maintenance phases. Also, the need for a large test program to maintain the E-6A aircraft's operability under P-Static weather conditions will be greatly reduced.

E-6A
PRECIPITATION STATIC ASSESSMENTS



JOEL HAINES

MIKE CLELLAND

NAVAIR AIR WARFARE CENTER AIRCRAFT DIVISION

PATUXENT RIVER, MARYLAND 20670-5304

E-6 HARDNESS MAINTENANCE & SURVEILLANCE PROGRAM

- HARDNESS MAINTENANCE
  - Comprehensive Procedures To Ensure That Fleet Operations, Logistic Support, and / or Maintenance Do Not Degrade The Designed Hardness
- HARDNESS SURVEILLANCE
  - System Level And Field Surveillance Tests & Inspections Performed Throughout The Aircraft Life-Cycle To Monitor Hardness Integrity

E-6 HARDNESS MAINTENANCE

- PROCEDURES HAVE BEEN DEVELOPED TO CONTROL, DETECT, AND CORRECT HARDNESS DEGRADATIONS AND FAILURES
  - Maintenance Personnel Are Trained In The Hardness Critical Process
  - Hardness Features Are Identified As Hardness Critical Items In All Maintenance Publications
  - Hardness Protection Device Inspections Are Integrated Into Scheduled Maintenance Program
- SOUND MAINTENANCE PRACTICES ARE KEY TO ENSURING HARDNESS INTEGRITY

E-6 HARDNESS SURVEILLANCE

- SYSTEM LEVEL TESTS
- FIELD SURVEILLANCE TESTS
- FIELD SURVEILLANCE INSPECTIONS
- P-STATIC ASSESSMENTS

E-6 HM / HS TEAM

- PERFORM SYSTEM LEVEL HARDNESS ASSURANCE & SURVEILLANCE TESTS
- DEVELOP & MAINTAIN THE E-6 EMP HM/HS DATABASE
- EVALUATE & DEVELOP TEST EQUIPMENT CAPABLE OF MONITORING & DETECTING EMP HARDNESS DEGRADATION

E-6 HM / HS TEAM

- PROVIDE ON-SITE LIFE-CYCLE EMP HM/HS TECHNICAL & ENGINEERING SUPPORT TO THE FLEET
- PARTICIPATE IN ENHANCED PHASE MAINTENANCE ACTIVITIES
- CONDUCT P-STATIC ASSESSMENTS

DEFINITION OF P-STATIC

- WHAT IS P-STATIC
  - Short For Precipitation Static
  - Charge That Builds Up On The Surface Of An Aircraft From Static Electricity

P-STATIC CHARGE BUILD-UP

- MAXIMUM CHARGE DENSITY IN-FLIGHT
  - 20 υA/ft^2 Current Density
- ACTUAL TESTING CONDITIONS
  - 20 υA/ft^2 At 40 kV

P-STATIC DISTRIBUTION PROCESS

- WHAT DOES P-STATIC CHARGE DO
  - Distributes Around Aircraft Structure
  - Uneven "Pockets" Of Charge May Be Created
  - Can Cause 3 Types Of Electrical Phenomena To Occur:
    - Arcing / Sparking
    - Corona Discharge
    - Streamering

EFFECTS OF P-STATIC

- WHAT EFFECTS DOES P-STATIC HAVE
  - High Level Of Stored Charge Potential On Aircraft
  - Creates EMI / RFI On Aircraft Equipment
  - May Cause Interference, Damage, Or Failure In Avionics
  - Hazardous To Personnel

STATIC DISCHARGERS

- PURPOSE OF STATIC DISCHARGERS
  - To "Bleed" Excess Current From Trailing Edges, Keeping Current And Voltage Levels Down
- NEED TO BE PROPERLY BONDED AND FUNCTIONING

AIRFRAME BONDING

- AIRFRAME SHOULD BE BONDED PROPERLY
  - Avionics Bay Doors
  - Landing Gear Areas
  - Removable Panels
  - Engines
  - Tags, Rivets, Bolts, Etc.
  - Any Metal To Metal Contact Point
  - Isolated Composite Panels

P-STATIC TESTING

- P-STATIC TESTING
  - Broken Down Into 4 Parts
    - Safety Brief / Check
    - Discharging Systems Check
    - Passive Systems Test (PST)
    - Active Systems Test (AST)

DISCHARGING SYSTEMS CHECK

- CHECK OF STATIC DISCHARGERS (WICKS)
  - Base To Aircraft $< 2.5\ m\Omega$
  - Tip To Base: 6-200 MΩ Trailing Edge Mounted
    6-120 MΩ Tip Mounted
  - MIL-B-5087B Bonding
  - MIL-D-9129D P-Static Dischargers
  - MIL-E-6051D EMI
  - Current Dissipation Capability (Typical) 100υA

PASSIVE SYSTEMS TEST

- PST
  - Test Of Aircraft Bonding With Systems Inoperative
  - Find Bonding "Problem Areas"
  - 2 People Required:
    - Aircraft Sprayer
    - Safety Spotter / DC Power Supply Operator

PASSIVE SYSTEMS TEST (CONT.)

- PST TEST METHOD
  - "Spray" Entire Airframe Surface
  - Charge Level: 50 - 100 $\upsilon A/ft^2$
  - Record Bonding "Problem Areas"
  - Suggest Possible Fixes
- THINGS TO BE CAREFUL AROUND
  - Antennas
  - Open Avionics Panels

ACTIVE SYSTEMS TEST

- AST
  - Test Of Aircraft Bonding With Systems Operative
  - Respray "Problem Areas"
  - 3 People Required
    - Aircraft Sprayer
    - Safety Spotter / DC Power Supply Operator
    - Aircraft Systems Operator

ACTIVE SYSTEMS TEST (CONT.)

- AST TEST METHOD
  - "Spray" Only Problem Areas Found During PST
  - Charge Level 20 $\upsilon A/ft^2$
  - Check All Aircraft Avionics / Systems For Interference
  - Record Interference

ACTIVE SYSTEMS TEST (CONT.)

- AUDIO NOISE ON RADIOS
- VISUAL "GLITCHES" OR ABNORMALITIES IN DISPLAYS
- BIT FAILURES
- LOSS OF AVIONICS OPERATION
- LOSS IN SYSTEM CAPABILITY

E-6A P-STATIC ASSESSMENTS

- E-6A BuNo 164387, 154388, 164408, 164406
  - Each Had P-Static Assessment Performed
  - Each Assessment Had Similar Results
  - P-Static Database Will Document These Similarities

E-6A EMI TROUBLE SHOOTING

- E-6A BuNo 164408
  - Severe EMI, VHF/UHF Radios Inoperable
- P-STATIC ASSESSMENT PERFORMED
  - Isolated Panels
  - Isolated Lightning Diverter Strip
- BONDED LIGHTNING DIVERTER STRIP TO AIRCRAFT ALLEVIATED EMI PROBLEM

PROBLEM AREA LOCATION

PROBLEM AREA	LOCATION	THRESHOLD ($\upsilon A/ft^2$)	SUGGESTED FIX
1	#1 ENGINE STRUT ACCESS PANEL L10133-05	10	BOND PANEL TO AIRCRAFT
2	HF LIGHTNING ARRESTOR PANEL, TOP OF VERT STAB	20	BOND PANEL TO AIRCRAFT
3	2 HINGES ON AFT SIDE OF FLIGHT RECORDER PANEL, BOTTOM OF VERT STAB	12	BOND HINGES AND PANEL TO AIRCRAFT

TYPICAL P-STATIC TEST SCHEDULE

TEST PHASE	DURATION (hrs)
DISCHARGER SYSTEMS CHECK	2
PASSIVE SYSTEMS TEST	4
ACTIVE SYSTEMS TEST	4

BENEFITS OF P-STATIC TESTING

- IDENTIFY ELECTRICALLY ISOLATED AREAS
- EVALUATE STATIC WICK PERFORMANCE
- MEASURE STATIC WICK PARAMETERS
- TEST LIGHTNING DIVERTER STRIPS
- IDENTIFY AFFECTED AVIONICS

SUMMARY

- NO LARGE P-STATIC TEST PROGRAM REQUIRED
  - One Day Evaluations During Maintenance Cycle
  - Real Time Maintenance Actions To Fix Problem Areas

- PROVIDES QUICK LOOK BONDING CHECKS OVER THE ENTIRE AIRCRAFT